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Social Influence in HRI with Application to Social Robots for Rehabilitation

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Index Terms—socially assistive robots; social influence; persuasion; user studies; acceptability; machine learning; autonomy

I. INTRODUCTION

Social influence refers to an individual's attitudes and/or behaviours being influenced by others, whether implicit or explicit, such that *persuasion* and *compliance gaining* are instances of social influence [1] [2]. In human-human interaction (HHI), the desire to understand compliance and maximise social influence for persuasion has led to the development of theory and resulting strategies one can use in an attempt to leverage social influence, e.g. Cialdini's 'Weapons of Influence' [3]. Whilst a number of social human-robot interaction (HRI) studies have investigated the impact of different robot behaviours in compliance gaining/persuasion (e.g. [4]–[7]); established strategies for maximising this are yet to emerge, and it is unclear to what extent theories and strategies from HHI might apply.

The doctoral work presented in this abstract is primarily concerned with improving understanding of persuasion and social influence in HRI; and further how this can be utilised for socially assistive robots (SARs). Encouraging engagement with rehabilitative exercises is chosen as an example application scenario for grounding the research. Like many SAR applications (e.g. exercise encouragement [8], cognitive training [9], independent living support [10]) this essentially requires the robot to prompt/encourage particular user behaviours. Further, social influence is known to play a role in therapy compliance [11] [12], such that therapist-patient interactions/therapist strategies for encouraging compliance can be studied for best practice and design inspiration. A mutual shaping approach, which recognises the dynamic interaction between robotics and society [13] is taken across all of the work, with consideration given to acceptability of the proposed system/methods and methodological processes for conducting meaningful HRI design and research.

II. STUDY WITH THERAPISTS

An extensive qualitative study with therapists was undertaken in order to understand social influence in therapy and how socially assistive robots might be used in this context. The study consisted of 5 focus groups (total 20 participants),

8 individual interviews and 4 therapy session observations (3 therapists, 4 patients); and led to a number of design implications/requirements for SARs based on therapists' expert knowledge and best practices [14]. A key result was the importance of therapists' social influence in encouraging the patient, which raises interesting questions for social robots designed to do the same thing, addressed in the next section. Finally, this work yielded methodological insight concerning the use of user-centred and participatory design methods in this type of research. Beyond the immediate design recommendations described above, a number of mutual shaping effects and societal factors concerning SARs were generated; for example concerning the impact of and on the patient's immediate family, and whether the robot could ease relationship strain induced by family members trying to provide that motivational support/encouragement.

III. SOCIALLY PERSUASIVE ROBOTS

The Elaboration Likelihood Model (ELM) is a well established model of persuasion in HHI that identifies the importance of persuader cues (likeability and credibility) when attempting to persuade someone about something they have little interest in, motivation to do or ability to understand [15] [16]. Many social assistance scenarios fall into one or more of these categories. Persuasive strategies based on the ELM include citing *expertise*, displaying *goodwill* and emphasising *similarity* towards the receiver. An experimental study (4x between-subject conditions, N = 92 subjects) was conducted to test whether these strategies could increase how much therapeutic exercise participants would be willing to do with the Pepper robot, compared to a control in which the robot made neutral small talk [17]. Figure 1 shows the number of repetitions completed by participants in each condition; with the goodwill (24.8 ± 8.1 reps, $p < .001$) and similarity (25.3 ± 7.5 reps, $p < .001$) condition being significantly higher than the control condition (14.6 ± 8.2 reps). Credibility and likability of the robot, measured subjectively, did not vary across conditions however; and post-hoc interviews with participants considering the 'genuineness', acceptability and potentially deceptive nature of these behaviours indicate that participants had complex feelings regarding the robot in this context: "I felt like it was genuine but also I'm very aware that somebody else programmed it to be genuine, but I'm ok with

that because I feel like whoever had made the programme in the first place did want the person [exercising] to feel comfortable and to feel cared about...it's the intention behind it." (G12).

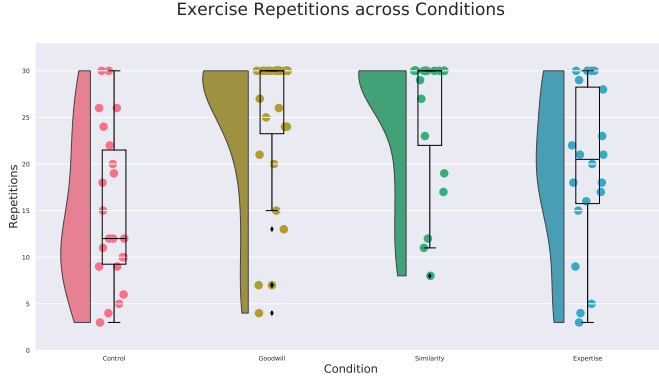


Fig. 1. Number of voluntary wrist turn repetitions done by participants across robot behaviour conditions designed to replicate persuasive strategies used by humans

Recent thinking on robot ethics suggests it may be desirable to minimise unnecessary anthropomorphism and deception [18]; however this is somewhat at odds with efforts in social robotics to create increasingly human/pet-like behaviours, with the motivation that such behaviours are required for social interaction [19]. An initial, within-subject online study ($N = 120$ subjects) was conducted to explore the impact of apparent social agency on perception of the Pepper robot. Participants were shown 3x videos representing 3x versions of the robot ('socially active', 'socially passive' and control) guiding a patient (actor) through an exercise session. The socially active robot referred to itself and suggested empathy e.g. "I know that exercising can be boring...I hope I can make exercising a bit more enjoyable for you", whereas the socially passive one made similar statements but with reference to the therapist/others e.g. "Many patients find exercising boring...perhaps working with me will make exercising a bit more enjoyable". The socially passive dialogue was therefore designed to demonstrate similar sociability to the socially active one but with less suggestion of social-emotional capabilities (i.e. less deceptive). In the control condition, the robot simply introduced itself and the exercise task. Perceived credibility and likeability did not vary significantly between the active and passive robots; however both of these robots were perceived significantly 'better' than the control (i.e. rated higher trustworthiness, goodwill, likeable etc.). If/how this would transfer to a live interaction scenario, such as the exercise scenario described above, is still to be investigated. However this provides initial evidence that a robot might be 'usefully social' without misrepresenting itself.

IV. DEVELOPING AN AUTONOMOUS ENCOURAGEMENT SYSTEM (*In Progress*)

The final piece of work to be completed as part of this doctoral research is the development of an autonomous encour-

agement system to be implemented on Pepper for encouraging the user through an exercise session. This essentially involves specifying and integrating required system inputs (state space), outputs (robot behaviours) and a method for intelligently selecting appropriately from these in real-time. Initial robot actions and state features/dimensions are relatively easily generated from work to date concerning therapist behaviours and persuasion, with examples given in Figure 2. It is not so simple however to extract basic logic rules between them that could form the basis of an autonomous system. A method of supervised learning, which has previously been used to generate progressively autonomous tutoring behaviours in an educational context [20], is currently being investigated for application to this context. This would involve setting up a live exercise interaction training scenario whereby a therapist or other 'encouragement expert' would wizard the robot, selecting which action should be taken and indicating which features make that action appropriate (through a wizard interface) in real-time, whilst the robot learns these mappings and gradually becomes autonomous. Note that significant work is required to identify the correct abstraction level of state features and the interface through which they would be presented to the teacher, as well as whether additional state information (e.g. heart rate) might be presented to the teacher via the interface - indicated by the dashed arrows in Figure 2. Non-intrusive teacher cues such as gaze tracking might also be investigated as a training cue in identifying relevant state features.

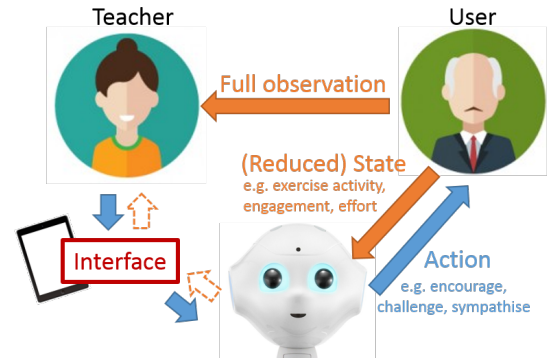


Fig. 2. Supervised learning set-up for generating autonomous encouragement behaviours based on the SPARC method [20].

V. CONCLUSION

This abstract presents doctoral research concerning the design of autonomous social robot behaviours for influencing user behaviour, as applied to therapy engagement. Resulting contributions include i) increased understanding of social influence & persuasion in HRI; ii) acceptability of anthropomorphic, potentially deceptive social robot behaviours in this context; iii) methodological insights for conducting meaningful HRI design & research; and iv) the application of supervised machine learning for encoding expert knowledge in socially assistive robots.

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